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Survival of Douglas-Fir Seedlings Sprayed with Atrazine, Terbacil, and 2,4-D

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Reference Abstract

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Grass control with atrazine increased survival of Douglas-fir seedlings when applied as a broadcast spray over new plantations on three summer-dry sites in southwestern Oregon. Terbacil and 2,4-D were less effective than atrazine. Conifer survival was excellent on four typical coastal sites in or near the fog belt along the southwest Oregon coast.

KEYWORDS: Herbicides (-regeneration, weed control (forest), atrazine, terbacil, 2,4-D, Douglas-fir, *Pseudotsuga menziesii*.

Research Summary

Research Paper PNW-256

1979

Atrazine, 2,4,-D, and atrazine plus 2,4,-D were applied as broadcast sprays to control grasses and forbs before conifer budbreak in new Douglas-fir plantations. Grass control did not increase survival or vigor of tree seedlings on four cool, moist sites in and near the fog belt along the southwest Oregon coast. On three drier sites in the Coast and Cascade Ranges, however, conifer survival on plots sprayed with atrazine was double (48 percent) that on plots without grass control (23 percent). Combining low volatile esters of 2,4-D with atrazine seems undesirable in broadcast sprays for grass and forb control in new plantations; Douglas-fir survival was less than on plots treated with the same amount of atrazine alone.

Both atrazine and terbacil effectively reduced grass cover the first summer after application, and a noticeable reduction was still evident early in the second summer. Terbacil, however, may have damaged the young Douglas-fir seedlings.

INTRODUCTION

Reforestation of sites occupied by grasses and forbs has long been a silvicultural problem on forest land in western Oregon. Herbaceous plants use much of the available soil moisture, and many planted conifers cannot survive this intense competition during the first dry summer seasons after planting. Mortality is greatest on dry inland sites east of the crest of the Coast Ranges.

On most sites, atrazine at a rate of 4 pounds active ingredient per acre (4.5 kg/ha) provides excellent grass control without damaging small Douglas-fir seedlings. Unfortunately, atrazine does not kill many broadleaf weeds. As a result, atrazine has often released broadleaf weeds as well as trees, reducing survival and growth of the young conifers.

To control broadleaf weeds as well as grasses, low volatile esters of 2,4-D have been added to atrazine sprays (Newton 1970), but several foresters indicated that this combination may have damaged newly planted conifers on some areas. This problem was studied in 1971. The combination of atrazine and 2,4-D was tested to determine its effect on survival and vigor of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) seedlings when broadcast sprayed on new plantations.

STUDY AREAS AND METHODS

Seven areas were selected for treatment: five on the Siskiyou National Forest in and near the fog belt on the coastal (western) slope of the Coast Ranges; two on drier sites east of the crest of the Coast Ranges. Four of the coastal sites were typical of most sites on the lower west slopes of the Coast Ranges. One coastal site near the Rogue River, however, was a droughty, dry site with vegetation similar to that of the dry interior valleys between the Coast and Cascade Ranges: second growth Douglas-fir was interspersed with oak (*Quercus* sp.), Pacific madrone (*Arbutus menziesii* Pursh), grassy balds, and rock outcrops. The other two dry sites were inland at an elevation of 2,800 ft (853 m) above sea level on the western slope of the Cascade Range in the Umpqua National Forest (fig. 1). All sites were in cutover areas occupied by mixtures of grasses and forbs with few woody plants.

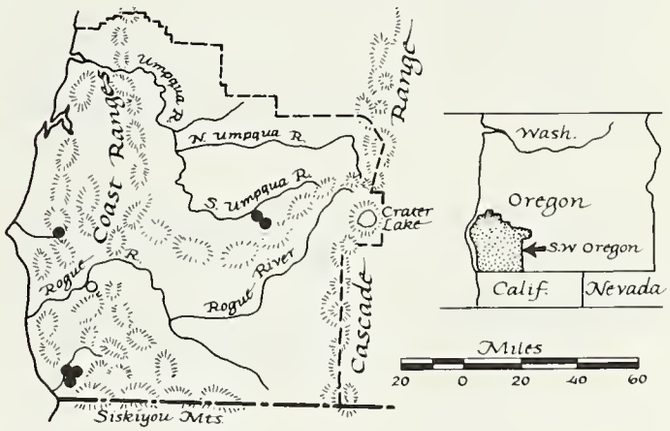

Figure 1.--Location of the seven study areas.

Rainfall on the coastal sites averages from 70 to more than 100 in (178 to 254 cm) per year, and cold, coastal fog periodically cools the environment and reduces drought effects even during summer. Rainfall on the west slope of the Cascade Range where the inland plots are located averages about 45 to 50 in (114 to 127 cm) per year, but summer drought is much more severe.

The study was designed as a randomized complete block experiment with one complete set of treatments on each of seven sites (fig. 1). On each site, five 21- x 105-ft (6.4- x 32.0-m) plots were planted with 125 2-0 Douglas-firs during late February and early March. After planting, four plots received one of four spray treatments; the fifth plot was left unsprayed as a control. A total of 4,375 trees were included in the experiment; 875 trees in the seven plots that received each spray treatment and a similar number in the unsprayed control plots.

Three herbicides and one combination of chemicals were applied as broadcast sprays over the conifers and competing vegetation (table 1). The chemicals were:

atrazine	2-chloro-4-(ethylamino)-6-(isopropylamino)-*s*-triazine
2,4-D	(2,4-dichlorophenoxy) acetic acid
terbacil	3-*tert*-butyl-5-chloro-6-methyluracil

Table 1--Treatments included in each replication

Treatment	Chemical		
	Atrazine	2,4-D	Terbacil
	- - - -Pounds per acre[1]/- - - - -		
none	[2]/0	0	0
Atrazine	[2]/4	0	0
2,4-D	0	1-1/2	0
Atrazine + 2,4-D	4	1-1/2	0
Terbacil	0	0	2

[1]/ Pounds active ingredient per acre for atrazine and terbacil; pounds acid equivalent for 2,4-D.

[2]/ 1 lb/acre = 1.12 kg/ha.

Because both atrazine and terbacil are soil-active herbicides primarily absorbed through roots of susceptible species, all sprays were applied during the period from mid-March through early April 1971, when sufficient rain could be expected after application to leach the chemicals into the soil. Weather conditions after treatment were normal: approximately 6.5 in (16.5 cm) of rain fell on the sprayed plots in the Cascade Range after treatment, followed by an extremely dry July, August, and early September.

All areas were examined during early June 1971, 2 months after treatment, to rate degree of grass and forb control, to record tree survival, and to note initial effects of the sprays on condition of the Douglas-fir seedlings before the beginning of the first summer drought period. A second examination was made in October 1971 to determine survival and vigor of the small conifers at the end of the first summer. A third examination was made in June 1972 to rate residual effects of the sprays on grasses and forbs--effects that might increase survival of the young conifers during the second dry summer season. A final examination was made in October 1972 to determine survival and vigor of the conifers at the end of the second summer.

RESULTS

Grass control does not seem necessary to establish Douglas-fir plantations in typical cool, moist habitats within or near the fog belt along the southwest Oregon coast during years when normal climatic conditions occur. Sprays to control grasses and forbs did not increase

survival or improve vigor of newly planted Douglas-firs on the four typical coastal sites (table 2). On such sites, therefore, expenditures for grass and forb control can be a waste of time, energy, and money. On coastal sites with shallow soils and limited soil moisture storage capacity, however, and on all inland sites, where summer drought is more severe, grass control is necessary to insure survival of young Douglas-firs planted in grass-forb communities.

Because grass and forb control did not improve survival or vigor of small Douglas-firs in the four plantations on cool, moist, coastal sites, evaluation of the chemicals can only be based upon their effectiveness on the three dry sites: two in the Cascade Range, and one droughty site deep within the Coast Ranges. Survival of Douglas-fir seedlings at the end of the second summer on the dry sites was far less than survival on typical coastal sites ($F_{1/5} = 207.726$, $P<0.001$).

Survival of Douglas-firs planted in untreated grass-forb plots was extremely low on the dry sites. The trees withstood and survived initial transplant shock and springtime environmental stresses very well, for survival and vigor of the conifers was good on all three areas in June before onset of the first summer drought. But only 45 percent of the trees survived the first summer, and only 23 percent were alive at the end of the second summer. In addition, most trees that survived in untreated plots were noticeably weakened and low in vigor after the second summer drought.

On the three dry sites, chemical sprays that reduced grass and forb competition appreciably increased Douglas-fir survival. Although the difference was not significant at the 5-percent level of probability in this small sample ($t_2 = 2.681$, $P>0.05$), atrazine at a rate of 4 pounds active ingredient per acre (4.5 kg/ha) seems the most effective broadcast spray for application over freshly planted Douglas-fir seedlings. Survival percentages for the three dry sites were:

Area	Atrazine	No spray
4	42	25
6	62	19
7	38	24

At the end of the second summer, 48 percent of the trees were alive on atrazine-sprayed plots; only 23 percent survived in the unsprayed control plots. In addition, far more trees were healthy and vigorous on atrazine-sprayed plots.

No other chemical spray was as effective as atrazine in this experiment. Fewer trees survived on plots sprayed with low volatile esters of 2,4,-D or atrazine combined with 2,4-D. Survival on terbacil-treated plots was also less than that on atrazine-treated plots.

Three treatments: (1) atrazine, (2) atrazine plus 2,4-D, and (3) terbacil provided good grass control throughout the first summer after spraying, and grass control was still readily evident at the beginning of the second summer (table 3). Atrazine combined with 2,4-D also appreciably reduced the forb cover the first summer after spraying. Terbacil was less effective on forbs the first summer, but some residual forb-control was still evident at the beginning of the second summer.

Table 2--Survival and condition of Douglas-fir seedlings after one application of herbicides for grass and forb control

Survival and condition	Beginning of summer[1]					End of summer[2]					End of second summer[2]				
	Control	Atrazine	2,4-D	Atrazine + 2,4-D	Terbacil	Control	Atrazine	2,4-D	Atrazine + 2,4-D	Terbacil	Control	Atrazine	2,4-D	Atrazine + 2,4-D	Terbacil
	Percent														
	COOL COASTAL SITES														
Survival	99	99	99	97	97	92	90	92	91	89	88	86	87	88	87
Condition															
Healthy	83	79	78	78	72	87	78	80	78	80	86	79	82	81	84
Weak	16	20	20	18	24	5	12	12	13	9	2	7	5	7	3
Dead	1	1	2	4	4	8	10	8	9	11	12	14	13	12	13
	DRY INLAND SITES														
Survival	96	94	96	93	93	45	70	51	59	62	23	48	32	34	37
Condition															
Healthy	72	74	68	59	66	24	51	30	33	38	10	29	14	18	23
Weak	24	20	28	33	24	21	19	21	26	24	13	19	18	16	14
Dead	4	6	4	8	10	55	30	49	41	38	77	52	68	66	63

[1] Survival data for all trees on each site; condition data for 40 percent of the trees at beginning of first summer.

[2] Survival and condition data for all trees at end of first and second summer.

Table 3--Grass and forb control after one application of herbicides in southwestern Oregon

Chemicals	Rate per acre	Grass control			Forb control		
		Spring 1971	Fall 1971	Spring 1972	Spring 1971	Fall 1971	Spring 1972
	Pounds[1/]	Percent control					
		COASTAL SITES					
Control	0	0	0	0	0	0	0
Atrazine	4	90	89	2	1	6	3
Atrazine + 2,4-D	4 + 1½	84	83	11	16	19	0
2,4-D	1½	0	0	0	7	7	0
Terbacil	2	73	73	28	1	19	1
		INLAND SITES					
Control	0	0	0	0	0	0	0
Atrazine	4	74	71	37	7	10	0
Atrazine + 2,4-D	4 + 1½	75	76	20	69	63	0
2,4-D	1½	0	0	0	3	3	0
Terbacil	2	65	68	54	14	21	15

[1/] Pounds active ingredient per acre for atrazine and terbacil; pounds acid equivalent for 2,4-D. All chemicals were applied in water carriers.

DISCUSSION

Excellent survival of Douglas-fir seedlings planted in untreated grass and forb communities in and near the fog zone indicates that grass and forb control may not be necessary on typical coastal sites. Summer drought conditions are probably less severe than on inland sites. Adequate soil moisture storage, a high percentage of overcast days, and periodic fog evidently interact to reduce moisture stress in freshly planted tree seedlings. Stone (1957) showed that artificial dew (spray) increased the length of time ponderosa pine (*Pinus ponderosa* Laws.), incense-cedar (*Libocedrus decurrens* Torr.), and white fir (*Abies concolor* (Gord. and Glend.) Lindl.) survived after soil moisture had been depleted to the ultimate wilting point of sunflower. Cool coastal fog may have a similar effect and reduce moisture stress in Douglas-fir seedlings.

On the three dry sites, survival of Douglas-fir seedlings sprayed with 2,4-D or with a combination of 2,4-D and atrazine was less than survival of trees sprayed with atrazine alone. This strongly suggests that broadcast sprays of 2,4-D have an adverse effect on newly planted Douglas-fir seedlings experiencing transplant shock on summer-dry sites. On such sites, young Douglas-firs must also endure severe drought stress as well. The herbicidal effect of 2,4-D is evidently sufficient to tip the balance from survival to death for many trees on dry sites.

Better established trees in older plantations evidently can withstand any adverse effects of 2,4-D. In an earlier study (Gratkowski 1976), established Douglas-firs survived broadcast sprays of 3 lb active ingredient of atrazine plus 1/2 lb acid equivalent of 2,4-D per acre (3.4 kg atrazine plus 0.6 kg 2,4-D per ha).

In contrast to effects on established seedlings, the data from dry sites indicate that terbacil may damage freshly planted Douglas-fir seedlings. Although terbacil provided appreciable grass and forb control for two summers, survival of Douglas-fir seedlings was less than that obtained with atrazine. Herbicidal activity of terbacil has also been reported to vary with differences in soil type (Kratky and Warren 1973, Stewart and Beebe 1974). This variation further complicates silvicultural use of terbacil and favors use of atrazine in broadcast sprays for grass control in new plantations of Douglas-fir.

CONCLUSIONS

An important result of this study is the strong indication that grass control is not usually needed to establish Douglas-fir plantations in grass-forb communities at low elevations on the western slope of the Coast Ranges in southwest Oregon. Under normal climatic conditions, environmental stress--especially summer drought--is evidently ameliorated by fog on forest sites in and near the fog belt along the Oregon coast. On drier inland areas, where summer drought is more severe, and even on droughty sites in the Coast Ranges, grass control is needed to insure survival of new Douglas-fir plantations. Almost

all forest areas east of the crest of the Coast Ranges can be considered dry sites.

On dry sites, herbicidal sprays broadcast over the trees, grasses, and forbs in new Douglas-fir plantations effectively controlled grasses and increased survival of the tree seedlings. A more advisable procedure, however, would be to use the herbicide, for site preparation *before* planting. Damage to the small, susceptible conifers would be minimized if spray solutions were not allowed to fall on their foliage.

Atrazine applied in a water carrier at a rate of 4 lb active ingredient per acre (4.5 kg/ha) was the most effective treatment after planting on the three drier areas in this study. Atrazine provided excellent grass control and resulted in best survival of Douglas-fir seedlings at the end of the second summer after planting. Survival on atrazine-sprayed plots was more than double that of trees in untreated control plots (48 percent vs. 23 percent).

Results of this experiment strongly suggest that low volatile esters of 2,4-D should not be added to atrazine in broadcast sprays to control forbs in new plantations of Douglas-fir on forest sites east of the crest of the Coast Ranges. This combination of herbicides (probably the 2,4-D component) may have damaged or killed weaker trees that were suffering transplant shock and environmental stress during the dry summer season. Early spring application of atrazine alone at a rate of 4 pounds active ingredient per acre is a far better treatment.

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Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

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Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

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